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DEVELOPMENT OF CAMOUFLAGED BODY COUPLED RADIO TRANSMITTERS

K. Ikrath, et al

Army Electronics Command
Fort Monmouth, New Jersey

April 1973

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13. ABSTRACT

Design, operation and performance of an experimental camouflage body coupled radio transmitter are described. The radiation mechanisms are elucidated by the results of signal transmission experiments in different local environments and in relation to radiation from a conventional whip antenna.

Corresponding implications with regard to radio communications in open terrain, dense vegetation and urban environments are discussed.

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DEVELOPMENT OF CAMOUFLAGED BODY COUPLED RADIO TRANSMITTERS

by

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1. Technical Background and Objectives

Conventional manpack type HF and VHF radio sets are usually equipped with whip antennas. These linear electrical antennas are very efficient RF radiators when they are operated vertically above ground in open terrains. However, whip antennas lose their effectiveness as RF radiators in water-permeated dense jungle vegetation and in the man made urban jungles of steel and concrete. Instead of serving as efficient radio communications devices, whip antennas tend to become in these jungle environments mechanical obstructions that hinder the radio operator's movements; however, the EM and mechanical mismatch between whip antennas and the natural and man made jungle media tends to reduce only quality and reliability of communications, whereas, the recognizability of a radio operator by virtue of his whip antenna tends to reduce his chances of survival, particularly under combat conditions in urban jungles. Yet, in carrying out ECOM's "Communications via Dense Difficult Media Research and Development Program," it became evident that the species "Homo Sapiens" is not only the most difficult communications medium, but it became also clear that its fine structure could be exploited to overcome the communications blocking effectiveness of its own gross structures, similarly as in the case of live trees and forests.[1] Thus, as a part of the Research and Development Program, the subsequently body coupled radio transmitter circuits were designed and constructed so as to evolve novel unconventional manpack type radio sets which operate efficiently on the human body under camouflage clothing and in close proximity to or in direct contact with vegetation or in close proximity to and or in conjunction with urban structures and vehicles.

2. Interaction of Human Body with EM Fields - Safety Considerations

Measurements by J. B. Andersons and P. Balling of the Technical University, Denmark, showed that the human body can serve as a radio transmitter antenna.[2] However, in contrast to metal rod antennas, the thick human body cylinder does not resonate at VHF frequencies which are related to its length. Furthermore, the problem of coupling a lumped circuit type EM signal source to the human body without evoking excessively dissipative eddy current losses remains to be solved in practice in the field. These dissipative eddy currents are generated on the inside body tissues when the human body is immersed into strongly inhomogeneous EM fields. Insofar as the different body tissues have different resistivities,[3] e.g. vascular tissues about 100 Ohm.cm, bone tissues about 900 Ohm.cm, fat about 5000 Ohm.cm, epidermis about 10^4 Ohm.cm, the distribution and the intensities of induced eddy currents and EM force fields inside the body are governed by the locations of different tissues relative to each other and in relation to the applied EM field configuration and by the frequency. The corresponding susceptibilities to electrical injuries of body tissues and organs govern the precautions used in performing maintenance work on live high tension lines.[4] For this purpose, critical average parameters such as average body resistance (ρ = 100 Ohm.cm), average dielectric permittivity (ε_{rel} - 80) and empirical formulas, formulas for a man's effective surface area, volume and related external capacitance (C_o = 40 to 80 picofarads) are being used to derive the

internal fields and currents as functions of the externally applied source field.[5,6] For example, the "Effective Surface Area S" in square centimeters of a man that is H centimeters tall and weighs W kilograms is calculated by the formula:

$$S/cm^2 = (71.84) \cdot \left[W/kg \right]^{0.425} \cdot \left[H/cm \right]^{0.725}$$

whereas his effective volume is defined by that of an ellipsoid with a major axes 2a = H and with a major to minor axes ratio a/b = 4.5. An important criteria for the susceptibility to electrical injury of specific body tissues is the ratio of their surface charge density " σ " and of their internal electrical polarization "P". In the alternating current case the ratio can be identified as equivalent to the ratio of a critical frequency "f_c" and of the operating frequency "f". The critical frequency is defined in this case by

$$f_c = \frac{1}{2\pi} \cdot \frac{\varkappa}{\varepsilon - \varepsilon_0}$$

where " $\varkappa$ " is the electrical conductivity (in Amp/Voltmeter) and where " ε " and " ε_0 " are respectively the dielectric permittivity of the tissue and of free space (in Amp.sec/Voltmeter).* With the average body conductivity $\varkappa \approx 1 \frac{mohs}{m}$ and dielectric permittivity

$\varepsilon = 80 \cdot \varepsilon_0 = \frac{80 \times 10^3}{36\pi} \times 10^{-12} \frac{A \cdot s}{V}$ [illegible] critical average frequency becomes about $f_c \approx$ 200 MHz; it f[illegible] human body as a whole is essentially conductive at frequ[illegible] MHz. Since this part of the frequency spectrum is also [illegible] the development of body coupled camouflaged radio transm[illegible], related safety factors can be deduced from permissible current and power levels in the patient circuits of electromedical instruments and therapy equipments which operate in this frequency range. For example "Faradization" involves the insertion of pulsed and or sinusoidal currents into selected parts of the human body at

---

$$^* \frac{|\sigma|}{|P|} = \frac{|J/j\omega|}{(\varepsilon-\varepsilon_0)\cdot|E|} = \frac{\frac{\varkappa|E|}{\omega}}{(\varepsilon-\varepsilon_0)\cdot|E|} = \frac{\frac{\varkappa}{\varepsilon-\varepsilon_0}}{\omega} = \frac{\omega_c}{\omega} = \frac{2\pi f_c}{2\pi f} = \frac{f_c}{f}$$

where J in Amp/m^2 = density of current flowing into the tissue

E in Volt/m = electrical field strength , $j = \sqrt{-1}$

frequencies ranging from 1 Hz to 5 kHz and at levels of up to maximal 10 milliamperes, whereas local electroanesthesia requires about up to 200 milliamperes. Similarly D'Arsonvalization Therapy with pulsed RF fields in the 1 to 3 MHz range generates currents in the patient circuit which range from 10 milliampere average to peaks as high as 500 milliamperes and corresponding average and peak power levels from two to maximal 50 watts. Approximately the same average and pulse peak current and power levels are employed for "Short-Wave Diathermy" treatments in the 1 to 100 MHz frequency range, whereas for "Cauterization" up to 600 watt peak power may be applied in form of extremely short pulses.

Obviously some degree of electro-diathermy treatment of the radio operator is unavoidable in the attempt to enlist his body for the emanation of RF signals, either directly or indirectly in conjunction with surrounding vegetation and or urban structures. However, considering electro-medical therapy data it is evident that the nominal 1 watt RF output from the subsequently described experimental body coupled radio transmitter circuit cannot possibly effect any physical or mental deterioration or improvements of their operators, this writer included.

3. Design and Operation of Body Coupled Hemac Transmitters

It has been pointed out before that the resistivities of human body tissues and organs vary over a very wide range; one must, therefore, expect that the interaction between the inhomogeneous human body and strongly inhomogeneous primary EM source fields as generated by any coupler, Hybrid Electro Magnetic Antenna Coupler (HEMAC) included, produces a strongly inhomogeneous resultant field configuration; it follows that the radiation field patterns from body coupled transmitters will be strongly influenced by the geometry and by the position of the coupler on the body as well as by the operating frequency, particularly at the higher frequencies where some body tissues are in the dielectric regime, whereas, others are in the conductive regime. Thus, as a beginning of the attempt to exploit human bodies as camouflage radio transmitter antennas, we have chosen the low HF frequency of 4.2 MHz at which the conductive regime dominates the interaction between body tissues and primary source fields and where both the flexible HEMAC coil and the body are essentially lumped circuit type elements which are small compared to the wavelength.* The transmitter circuit

---

* For the average body tissue resistivity ρ = 100 Ohm.cm i.e. $\varkappa$ = 1 Mohs/m the skin depth becomes:

$$\delta = \sqrt{\frac{2}{\omega \varkappa \mu_0}} = \sqrt{\frac{2}{2\pi f \varkappa \, 0.4\pi \times 10^{-6}}} \approx \frac{10^3}{2\sqrt{\varkappa f}} = \frac{10^3}{2\sqrt{1 \times 4 \times 10^6}} = 0.25 \, m$$

consists of a crystal-controlled 4.2 MHz transistor oscillator that feeds a single transistor power output stage. This type of XMTR circuit is used widely by radio amateurs as a signal source for the alignment and calibration of HF antennas.[7] The output circuit has been modified to drive either a whip or a body coupled HEMAC coil. The circuit diagram of the XMTR is shown in Fig. 1. The circuit is packaged in a 6 x 4 x 4 inch wide aluminum box which is attached to a similar 5 x 4 x 3 inch wide box that contains the battery, and RF output milliampere meter and the HEMAC tuning capacitor. The complete transmitter package is shown in Figure 2 in conjunction with a center coil resonator loaded 34 inch long whip antenna. This whip antenna is used as reference antenna for the subsequently described measurements and performance tests with the body coupled HEMAC transmitter. A typical deployment of the body coupled HEMAC transmitter is shown in Fig. 3. The flexible HEMAC coil has 26 turns, a pitch of about 3 cm to 5 cm and a coil diameter of about 6 cm. The transmitter output is connected across 4 and 1/2 turns at one end of the coil; the other end of the coil connects via the RF milliampere meter to the tuning circuit in the transmitter box. The roles of the Hemac coil and of the human body in the operation of the body coupled transmitter are reflected by the data in Figures 4A to G. The data in Figures 4A to G give the relative field strength levels in decibels as functions of positioning and of orientations of the XMTR Hemac coil and of the reference whip in relation to the body and to the distant receiver. The field strength levels were measured with an EMC-25 RFI Analyzer-Field Strength Meter using its whip antenna mounted vertically on the roof of a weapons carrier vehicle about 150 to 200 feet from the XMTR location in grass and brush covered flat terrain in the Wayside, N.J. Test Area. The influence of the belly on the directivity of RF radiation from the body coupled Hemac XMTR is seen by comparing the data for horizontal positions A and B of the XMTR on and off the body. Of particular interest, position A from the stomach forward directed radiation maximum (0 dB) and backward directed minimum (-5 dB) relative to the almost omnidirectional radiation (+6 dB to +4 dB) from the Hemac XMTR in position B. Furthermore, comparing the data for the vertical positions C and D of the Hemac XMTR on and off the body, one recognizes the deformation of the double lobed essentially magnetic loop type radiation pattern (sideward maxima +15 and +14 dB) in position D of the Hemac XMTR into a broad single lobed pattern in position C (forward minimum 10 dB and backward maximum 21 dB) as a result of close coupling with the body. The backward maximum (21 dB) is in this case equal to the levels obtained with the reference whip antenna in position E. The data for the whip in position E and F, close to and off from the body, indicate little coupling between the body and the whip; evidently because the upper part of the whip antenna extends above the head such that the whip's resonator coil is about at eye level above ground. The strong coupling of the Hemac relative to that of whip Hemac coil to the body shows up also in the unsymmetrical position G where the Hemac XMTR is carried across one shoulder and under the opposite arm. In this position on the body minimum radiation (7 dB) is to the side where the arm covers part of the Hemac coil and the forward and backward radiation maxima (17 to 18 dB) are about equal. This position G of the Hemac XMTR on the body appeared to be most practical for use in the field and was therefore employed in the subsequently discussed transmission tests. It should be noted that while the Hemac is closely coupled to the body in position C, that the radiation efficiency is vastly increased over that in position D. (Decrease in absorption by body of Fig. 4, Pos. C over Pos. D)

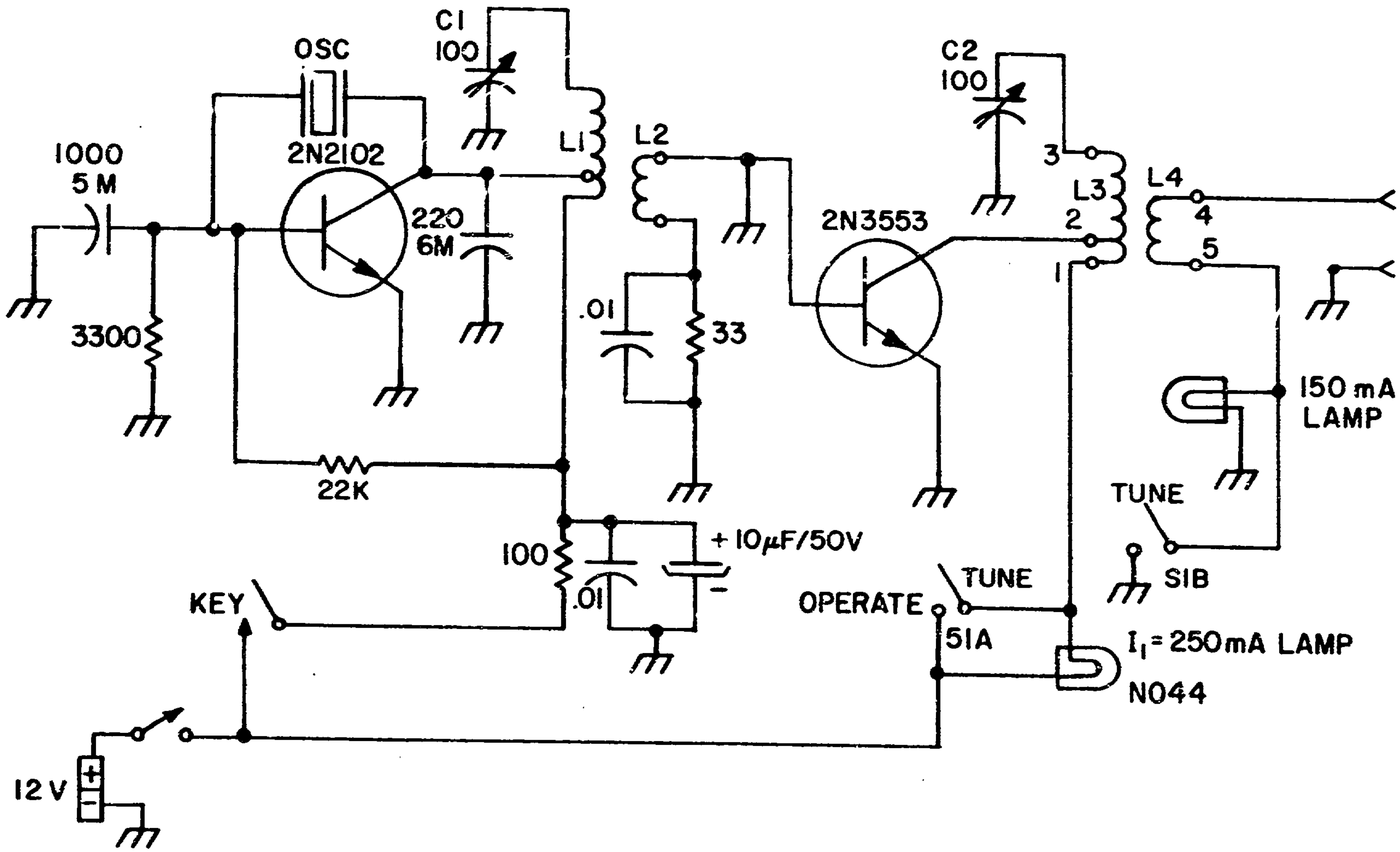


FIG. 1 - CIRCUIT DIAGRAM: 4.2 MHz - 1 WATT XMTR

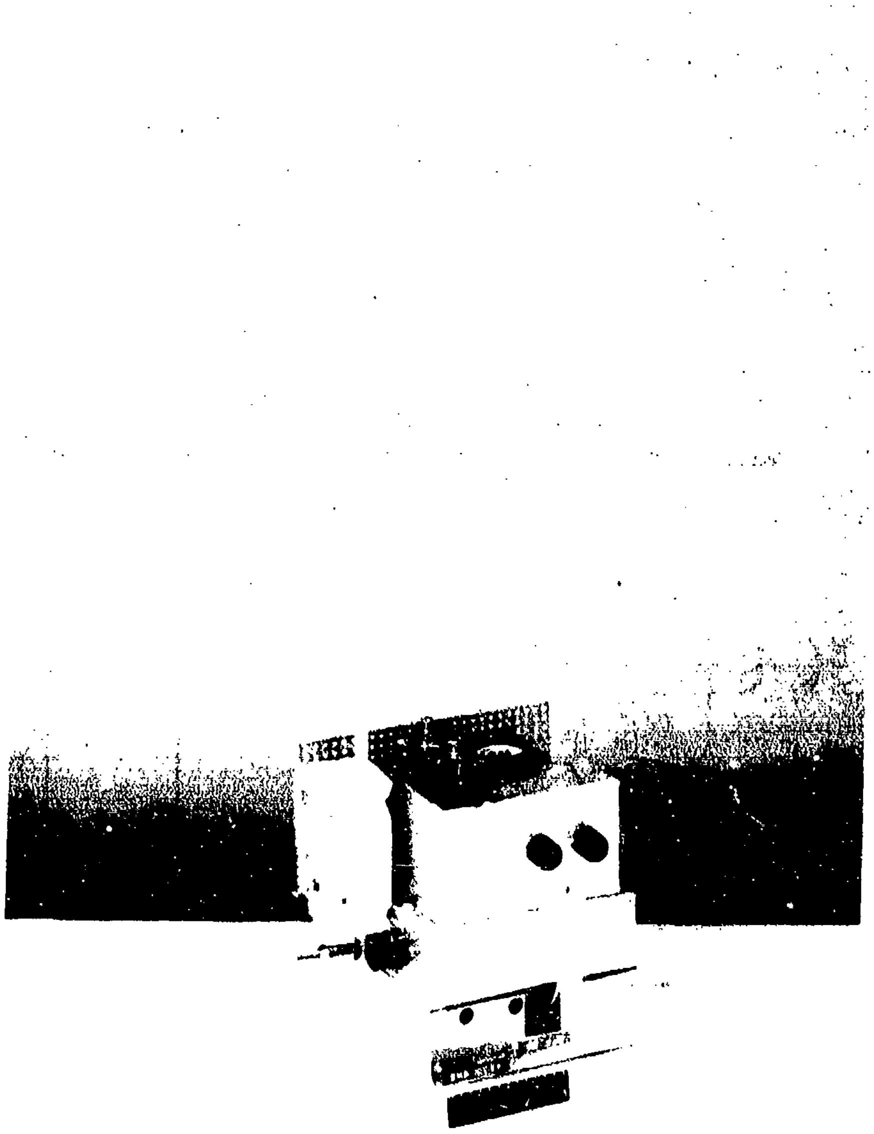
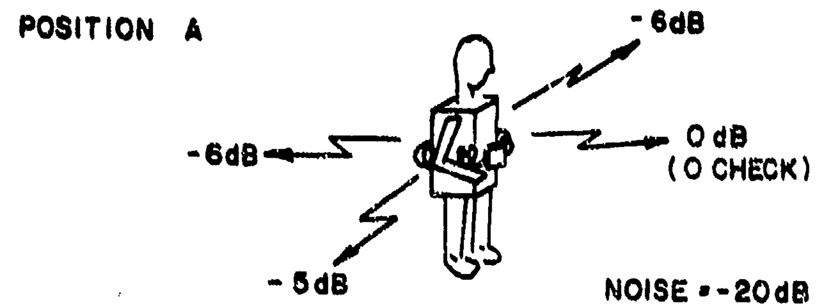
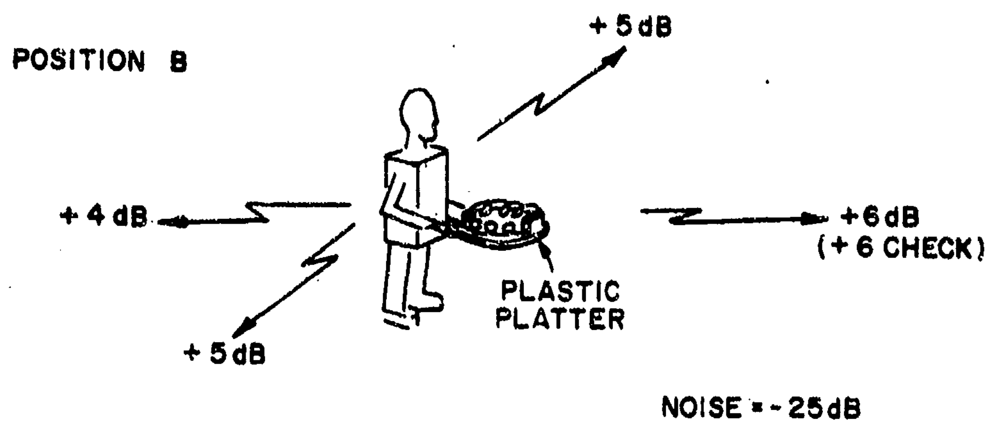


FIG. 2 - XMTR-Package with Reference Whip Antenna

FIG. 3 - Body Coupled HEMAC-XMTR





"Check" indicates a complete 360° pattern measurement with closure check. Such closure differences are attributable to human operator positioning and handling of antennas.

Fig. 4 (A and B). Relative Field-Strength Levels (dB) from Body Coupled 4.2-MHz Hemac XMTR, Wayside Test Area, 4 Dec. 1972.

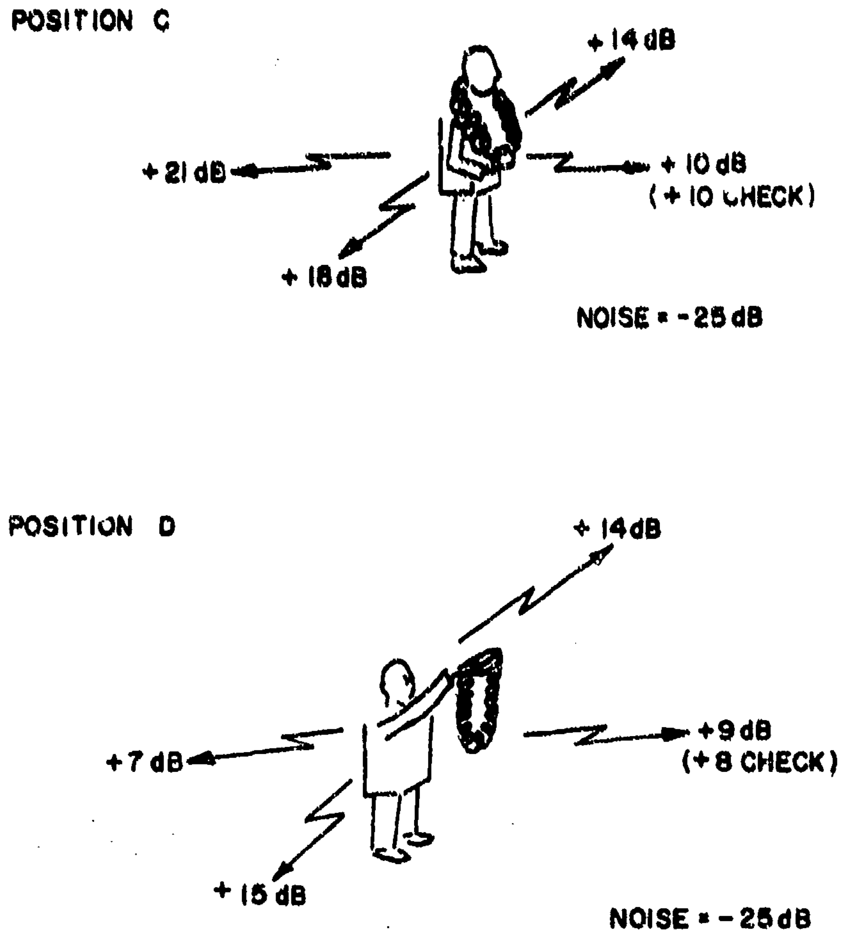
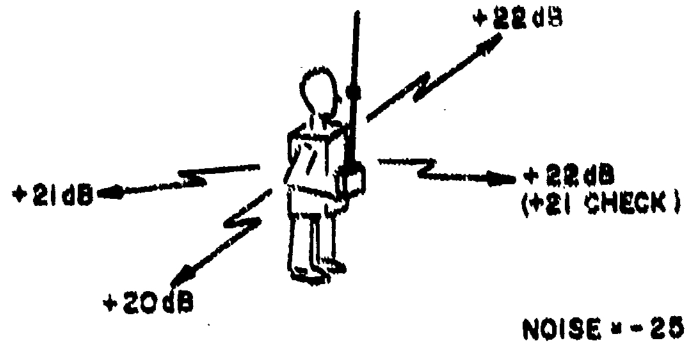


Fig. 4 (C and D). Relative Field-Strength Levels (dB) from Body Coupled 4.2-MHz Hemac XMTR, Wayside Test Area, 4 Dec. 1972.

POSITION E



POSITION F

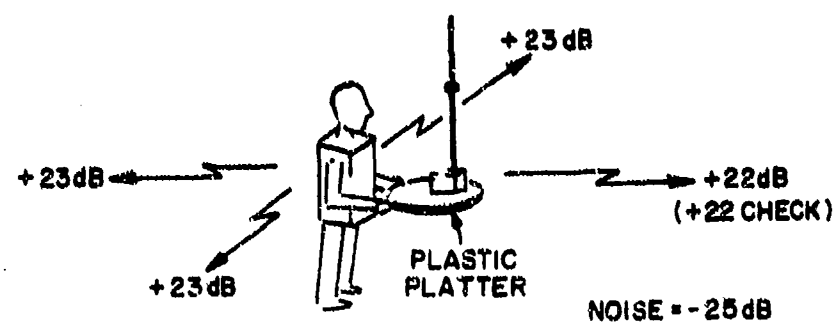
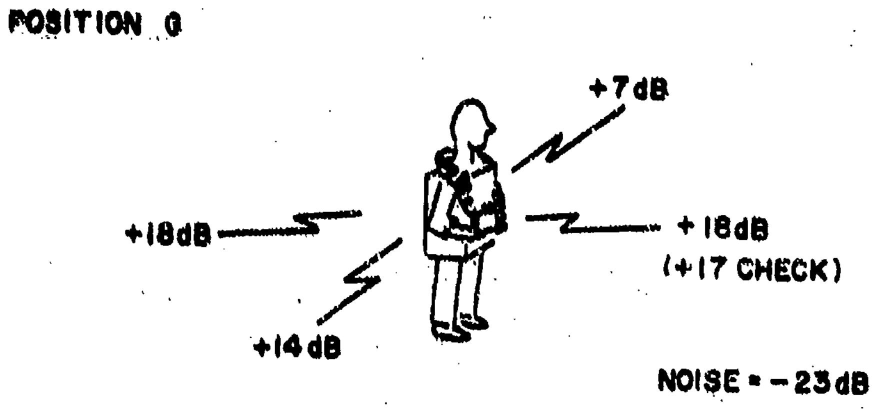


Fig. 4 (E and F). Relative Field-Strength Levels (dB) from 4.2-MHz Whip XMTR, Wayside Test Area, 4 Dec. 1972.



Remarks: All levels for positions A to G measured with EMC-25 RFI-Analyzer Field Strength Meter and with EMC-25 Whip Antenna mounted on roof of weapons carrier vehicle.

Fig. 4 (G). Relative Field-Strength Levels (dB) from Body Coupled 4.2-MHz Hemac XMTR, Wayside Test Area, 4 Dec. 1972.

4. Transmission Tests

The transmission tests with the body coupled Hemac XMTR and various receivers were motivated by the two basic objectives: to obtain practical transmission range data in environments where the body coupled Hemac XMTR is operated in close proximity or in direct contact with natural or man made obstructions which hinder and or degrade the operation and performance of conventional manpack type radio transmitters. The illustration and map of the Hexagon area in Figure 5 show a typical test setup and the locations of the body coupled XMTR operator in the proximity of such obstructions including the metal body of a passenger car. Keyed CW signals emitted from locations marked X on the map were received clearly at the location marked R using a PRC-74 radio set with a vertical whip antenna. Of significance, it is here that signals could be received from the body coupled Hemac XMTR when the XMTR operator remained sitting inside his car; the corresponding XMTR locations outside as well as inside the car are marked by X on the map in Fig. 5. The results of another transmission test in the Hexagon area are tabulated in Figure 6. In this case the emitted signals from the body coupled Hemac XMTR were received via the sloped wire-Delta Antenna at the Earle Radio Station using the EMC-25 RFI analyzer-field strength meter for the measurement of signal and noise levels and an R-390 radio set as a monitor. The signals remained audible in RFI noise using the R-390 radio receiver in the BFO mode when the body coupled Hemac XMTR operator moved into the Building 2525, Room 3202.*

A similar transmission test in which the EMC-25 RFI analyzer-field strength meter was used for measurement of signal and noise levels and an R-390 radio receiver as a signal monitor was conducted in the Evans Area. In this case, signals were received via the horizontal wire doublet antenna of Radio Station AD2XL in Building T-113. The Building T-113 receiver location is marked by R in the map in Figure 7 and the various XMTR locations are marked numerically from 1 to 7. The corresponding receiver log data are given in Figure 8. Of particular interest is here the observed enhancement of the signal emission by the metal body of the passenger car (locations 2 and 4) and by touching metal light and flag poles (locations 3 and 5).

For a comparison of the body coupled Hemac XMTR with the reference whip antenna, refer to the data in Figure 9. Here are given the signal levels as received at station AD2XL in the Evans Area (Bldg T-113) from the body coupled Hemac and from the center coil resonator loaded 34 inch long reference whip antenna. The respective signal levels as received via the horizontal doublet antenna are given in decibels read-off from the S-meter of the station's R-390 radio receiver. The data indicate that over larger distances in gullied terrain and with a horizontal wire doublet as receiver antenna, the body coupled Hemac and the reference whip yield about the same signal levels, even when Bill is replaced by Kurt as XMTR operator at random orientations of the operators.

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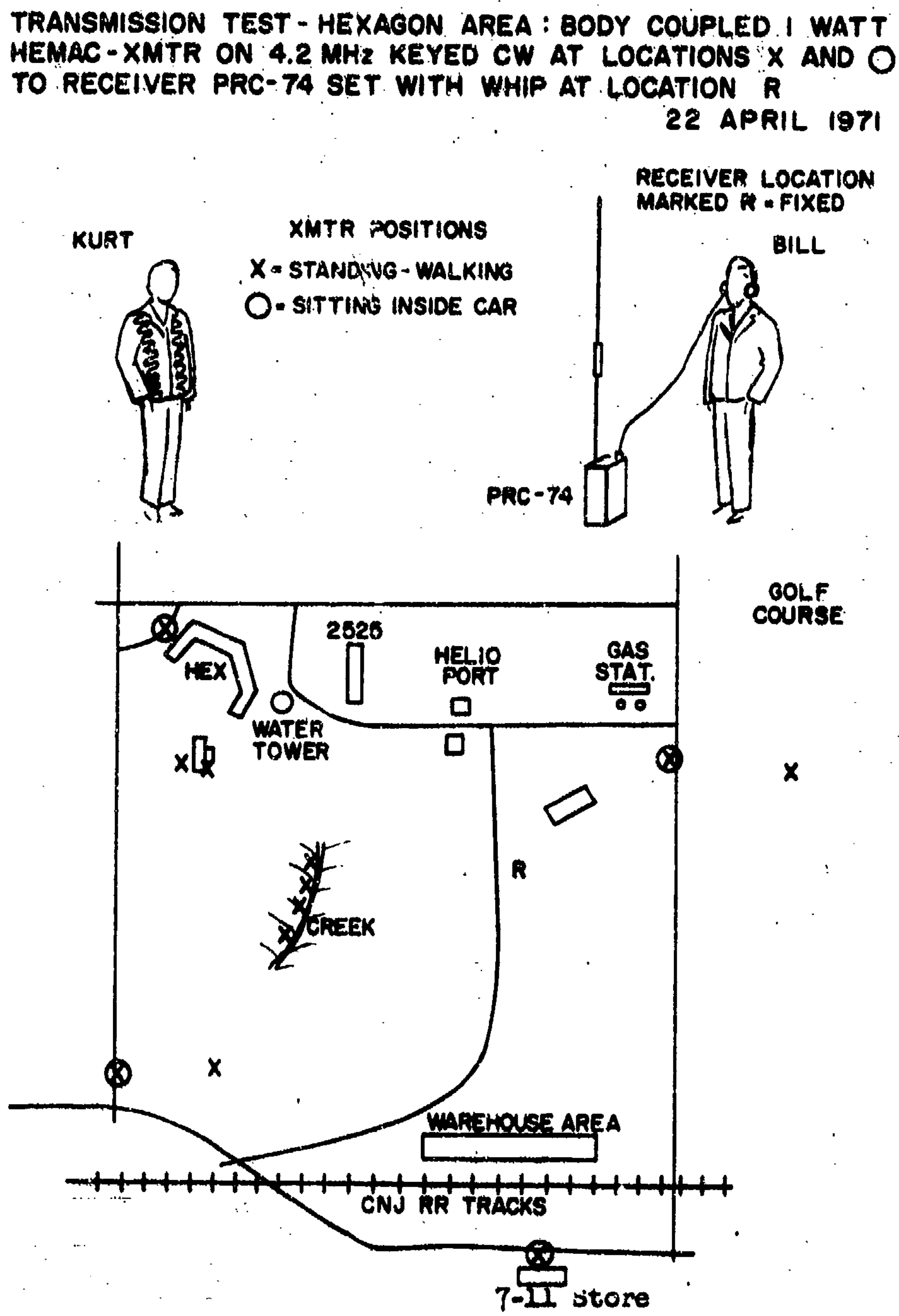
* Building 2525 has a metal roof.



Scale: 1" - 500'(Approximate)

FIG. 5 - Transmission Test Locations -
Hexagon Area - 22 April 1971

TRANSMISSION TEST: HEXAGON AREA-EARLE RADIO STATION: BODY COUPLED I WATT HEMAC XMTR ON 4.2 MHz KEYED CW TO RECEIVER (EMC-25) AT EARLE RADIO STATION

20 MAY 1971.

XMTR LOCATIONS AND POSITIONS	REL. RECEIVED LEVELS IN dB	
	SIGNAL + NOISE	NOISE
HEXAGON ROOF	60	25
HEXAGON YARD EXIT	35	25
BUSHES NEAR WATER TOWER	35	25
BLDG 2525 IN MR. BAUER'S OFFICE	BFO -AUDIBLE ABOVE NOISE	25

FIG. 6 - Transmission Test Data: Hexagon Area - Earle Radio Station - 20 May 1971

TRANSMISSION TEST - EVANS AREA: BODY COUPLED 1 WATT HEMAC XMTR ON 4.2 MHz KEYED CW AT LOCATIONS (1) THROUGH (7) TO RECEIVER STATION AD2XL LOCATED AT R IN BLDG T113.

23 APRIL 1971

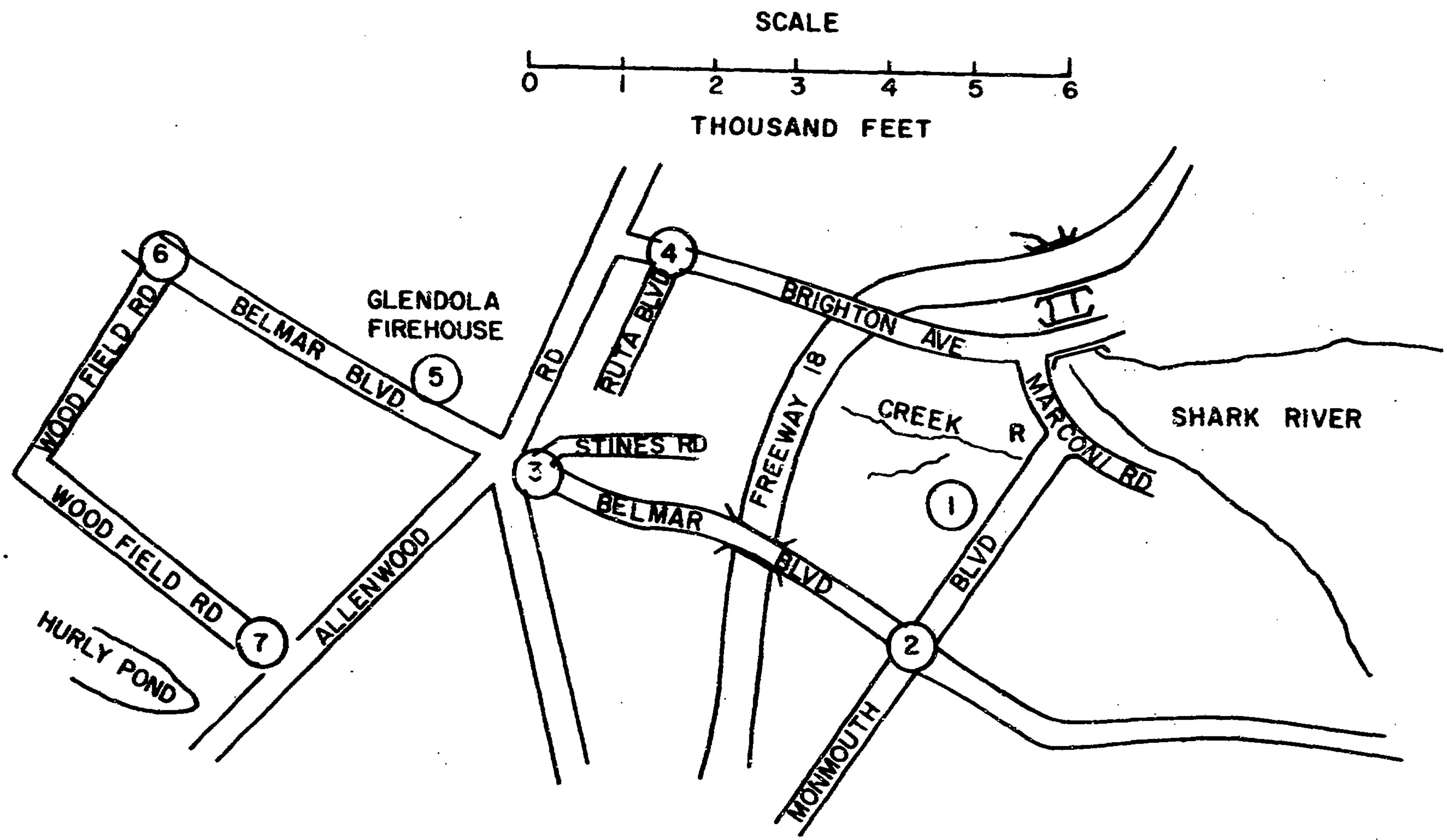


FIG. 7 - Transmission Test Locations - Evans Area - 23 April 1971

TRANSMISSION TEST - EVANS AREA: BODY COUPLED 1 WATT HEMAC XMTR ON 4.2 MHz KEYED CW AT LOCATIONS (1) THROUGH (7) TO RECEIVER STATION AD 2XL LOCATED AT R, BLD. T113 23 APRIL 1971

TIME	XMTR - LOCATIONS AND POSITIONS OUT AND INSIDE CAR			RECEIVED SIGNAL REL. LEVEL db (EMC-25)	RECEIVED SIGNAL BF-TONE QUALITY
16:12				0	LOUD CLEAR
16:13	1	OUTSIDE		-16	CLEAR
16:14		INSIDE		WEAK NOT READABLE	AUDIBLE
16:15	2	OUTSIDE	BELMAR MONMOUTH BLVD	WEAK NOT READABLE	AUDIBLE
16:16		INSIDE		-15	CLEAR
16:17	3	OUTSIDE	STINES RD BELMAR BLVD	WEAK NOT READABLE	AUDIBLE
16:18	3	TOUCH METAL LIGHT POLE	-11-	-16	CLEAR
16:19		INSIDE		-18	CLEAR
16:20		INSIDE		WEAK NOT READABLE	AUDIBLE
16:21	4	OUTSIDE	BRIGHTON AVE RUTA BLVD	WEAK NOT READABLE	AUDIBLE
16:22		INSIDE		-16	CLEAR
16:23	5	OUTSIDE	GLENDOLE FIRE HOUSE	IN NOISE	NOT AUDIBLE
16:24	5	TOUCH METAL FLAG POLE	-11-	-18	CLEAR
16:25	6	OUTSIDE	WOODFIELD AVE BELMAR BLVD	IN NOISE	NOT AUDIBLE
16:26	6	INSIDE	-11-	IN NOISE	NOT AUDIBLE
16:30	7	OUTSIDE	WOODFIELD AVE ALLENWOOD RD	IN NOISE	NOT AUDIBLE

FIG. 8 - Transmission Test Data:
Evans Area - 23 April 1971

TRANSMISSION TEST: EVANS AREA COMPARISON - BODY COUPLED HEMAC VERSUS CENTER COIL LOADED WHIP - 1 WATT XMTR ON 4.2 MHz KEYED CW TO RECEIVER STATION AD2XL IN BLDG T113.

24 MAY 1971

XMTR LOCATIONS	RELATIVE RECEIVED SIGNAL CARRIER LEVELS IN dB: FROM WHIP	RELATIVE RECEIVED SIGNAL CARRIER LEVELS IN dB: FROM HEMAC ON BILL K. BODY
(1) AT GATE TO TUNNEL SITE IN THE OPEN	60dB	55dB
(2) IN WOODS AT EDGE OF MEADOW	57dB	51 dB
(3) AT CREEK IN GULLY UNDER TREE	53dB	48dB
(4) MOVING ALONG TRAIL AT CREEKS BANKS	50dB	45 TO 53dB
(5) GLENDOLA FIREHOUSE	33dB	35dB

REMARKS: RECEIVED NOISE LEVEL = 25dB ALL LEVELS MEASURED WITH R390 RADIO RECEIVER

RECEIVED NEARFIELD LEVELS FROM BODY COUPLED HEMAC XMTR ON KURT = 68dB MAX.
ON BILL = 71dB MAX.

FIG. 9 - Transmission Test Data: Body Coupled HEMAC versus Whip Antenna - Evans Area, 24 May 1971

Bill's weight and height W_b = 73 Kg and H_b = 174 cm and he appears to be a more efficient antenna than Kurt who weighs W_k = 78 kilograms and is H_k = 187 cm tall. Using the previously given empirical formula for the effective surface area of a man and forming the ratio of the effective surface areas S_b of Bill over S_k of Kurt one gets in terms of decibels:

$$20 \cdot \log \frac{S_b}{S_k} \doteq -3.6 \text{ dB}$$

Evidently the observed difference in the maximal near field levels from the body coupled Hemac XMTR on Kurt (68 dB) and on Bill (71 dB) appears to be correlated with the ratio of Bill's and of Kurt's effective surface areas. Furthermore, the roles played here by the different polarizations of the transmitter and receiver antennas becomes evident from the results of the subsequently described measurements in the flat terrain of the Wayside Test Area where instead of a horizontal wire doublet antenna, a vertical 60 foot high wire suspended from a wooden pole was used as receiver antenna. The measurement results in form of received signal levels versus distance of the body coupled Hemac and of the reference whip XMTR are plotted in Figure 10 in conjunction with a map, the receiver and the locations. In this vertically polarized receiver antenna case and in the essentially flat terrain in the Wayside Test Area, signals from the whip are about 10 dB stronger than those emitted by the body coupled Hemac XMTR. This discussion of the transmission test results with the 4.2 MHz body coupled Hemac transmitter would not be complete without mentioning an operationally important handicap associated with the frequency choice. The chosen operating frequency of 4.2 MHz falls into an HF band which is loaded with signal emissions, mostly code and teletype, from power full stations all over the world. As a consequence, the RFI - noise levels are not only extremely high but change often rapidly, particularly during the afternoon hours. Though it is therefore evident that a body coupled Hemac XMTR as well as a whip XMTR operating on 4.2 MHz with 1 watt output power, has little chance to compete with the emissions from the powerful HF radio stations that pollute the lower HF frequency bands, the test results show that the applied body coupling principles are technically sound and useful. In this connection, it is also necessary to mention the results of preliminary tests in the Wayside Test Area where the performance of the 1 watt 4.2 MHz body coupled Hemac XMTR was compared with that of a similar 1 watt 8.275 body coupled Hemac XMTR using a 15 foot whip and the EMC-25 RFI analyzer-field strength meter as receiver.

The comparison of the data in Figure 11, as well as further qualitative test results indicate, that the 8.275 MHz noise levels are lower than the 4.2 MHz noise levels. However, the lower noise level at the higher frequency is not the only reason for the superior performance of the 8.275 MHz XMTR.*

*e.g., In contrast to 4.2 MHz transmissions, the 8.275 MHz transmissions from the guard booth at Gate 6 (location G map in Fig. 10) could be received on Feb. 10, 71 at 19.5 dB over 18 dB using the same 15 foot whip EMC-25 receiver set-up.

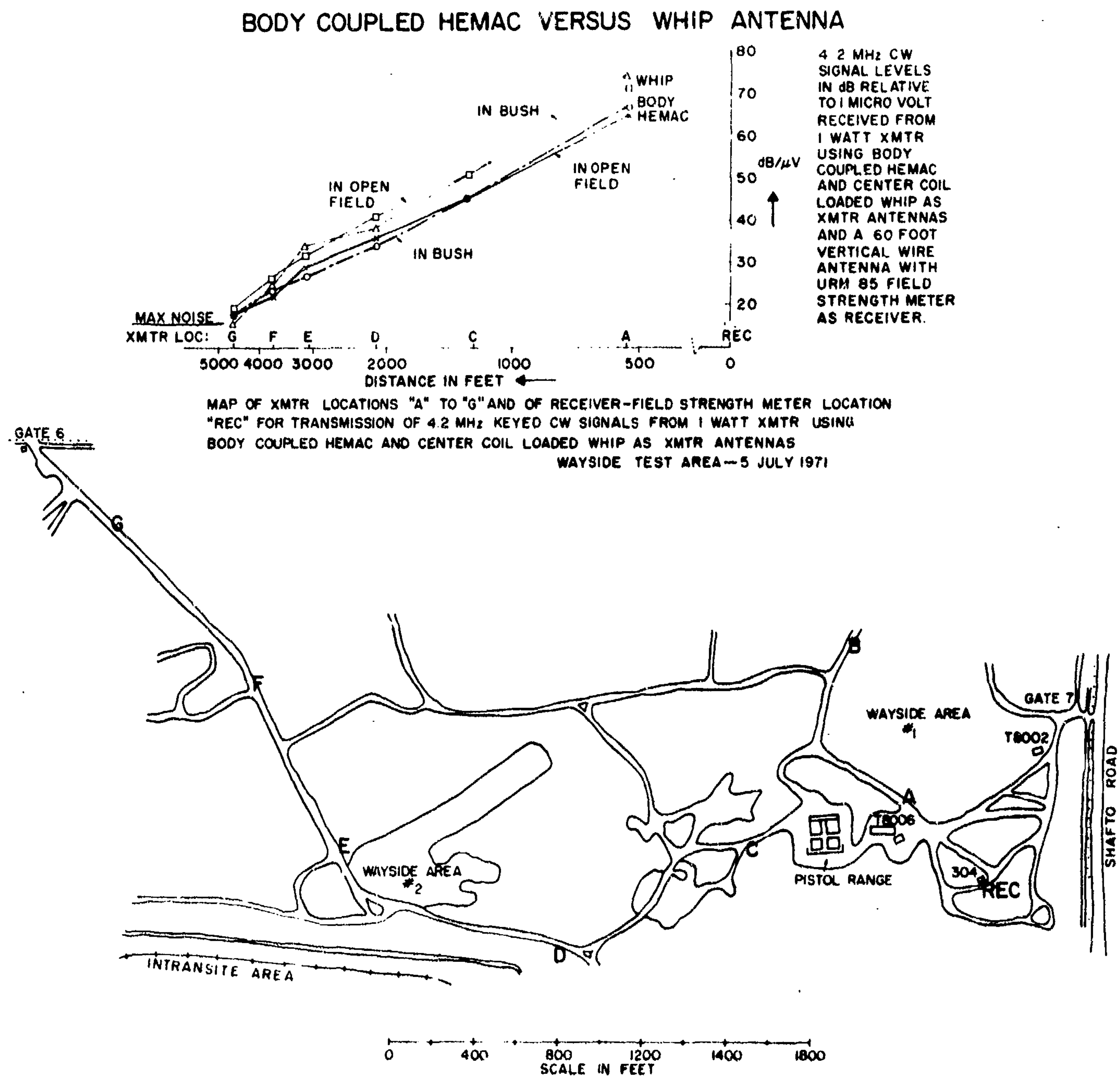


FIG. 10 - Transmission Test Data:
Body Coupled HEMAC versus
Whip Antenna - Wayside Test
Area - 5 July 71

TRANSMISSION TEST: COMPARISON OF KEYED CW SIGNAL TRANSMISSIONS FROM SIMILAR BODY COUPLED HEMAC I WATT TRANSMITTERS OPERATING ON RESPECTIVELY 4.2 MHz AND 8.275 MHz, WAYSIDE TEST AREA. FEB 9 AND 10, 1972.

DATE	XMTR LOC LASER SHACK BLDG	RECEIVED LEVELS IN dB (EMC-25)			
		4.2 MHz		8.275 MHz	
		(S+N)MAX	N	(S+N)MAX	N
9 FEB	OUTSIDE INSIDE	34 30	28	42 38	24
10 FEB	OUTSIDE INSIDE	34 31	28	40 34	18

REMARKS: 1) ALL LEVELS MEASURED WITH EMC-25 RFI ANALYZER-FIELD STRENGTH METER CONNECTED TO 15 FT. HIGH WHIP-ANTENNA ON ROOF OF WOODEN HUT BLDG.

2) 8.275 MHz EMISSION FROM GUARD BOOTH AT GATE 6, COMES THROUGH (19.5 dB OVER 18 dB); 4.2 MHz DOES NOT

FIG. 11 - Transmission Test Data: Body Coupled HEMAC 4.2 MHz versus 8.275 MHz - Wayside Test Area - 9 and 10 Feb 72

increasing frequency the Hemac coil loses its lumped circuit type behavior and the RF coupling to the body becomes more sensitive to the body's structural and material heterogeneity, the results of the transmission tests lead to the following conclusions.

5. Conclusions

On the basis of practical experience obtained thus far with the lab constructed 4.2 MHz and 8.275 MHz body coupled Hemac transmitters and upon consideration of the RF radiation and absorption mechanisms involved, it is evident that the human body as a whole, or parts of it, can play a highly useful role as a camouflage antenna or antenna element at higher HF and possibly lower VHF frequencies. To realize this role of the human body by itself or in conjunction with elements in its immediate natural or man made environments the following recommendations are made.

6. Recommendations

a. Complete performance evaluation of the lab constructed 8.275 MHz body coupled Hemac - 1 watt XMTR.

b. Substitute standard commercial or military radio transceiver sets for the lab constructed XMTR and modify Hemac circuit accordingly.

c. Investigate radiation field intensities as functions of frequency and input power level for given position and orientation of the Hemac on the body and in conjunction with the biomedical aspects as in:

(1) Open field environments

(2) Dense vegetation environments

(3) Urban environments

7. Objective

A camouflage body coupled Hemac radio set which is competitive with conventional whip antenna equipped manpack radio sets in open terrain and superior in natural and urban jungle environments.

8. Acknowledgments

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The electromedical data were extracted from lectures on "Electromedical Instrumentation" by Prof. Skudroyk, TH., Vienna, Austria.

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